3.2 SUPPLY-SIDE MANAGEMENT FOR THE LAKE OKEECHOBEE SERVICE AREA

Introduction

The entire area served by Lake Okeechobee, collectively known as the Lake Okeechobee Service Area or LOSA, is comprised of four basins: North Shore, Caloosahatchee River, St. Lucie River, the Everglades Agricultural Area. These basins (also referred to as individual Lake Okeechobee Service Areas or LOSAs) are located around the lake [Fig. 1.3.1(d)]. Their demands for water are primarily for irrigation purposes. Since lake water is not unlimited, the demand for this resource must be managed and distributed in an equitable manner. In times of sufficient storage irrigation requirements are met entirely -- water use is said to be unrestricted and the amount of water available for use (maximum allowable demand or, simply, allocation) is equal to irrigation requirements or demands. However, in times of shortage, water use may be restricted resulting in allocations being lower than the demands. The total irrigated acreage of these four basins is the basis for calculating irrigation requirements and allocations for the entire service area. (Allocation of lake water to the Lower East Coast Service Areas or LECSAs for water supply purposes is handled differently from the LOSA, as will be shown later.) Table 3.2.1 lists the four LOSAs, the subbasins from within, irrigated acreages, and associated control structures (Hall, 1991).

Following one of the most severe droughts on record, the District implemented the Water Shortage Plan in 1982. Lake Okeechobee reached its all-time record low of 9.75 ft NGVD during the summer of 1981. The plan, which was subsequently updated (SFWMD, 1991), provides specific guidelines for water restrictions based on use type and severity of drought. The amount of reduction range from 15% to 60% of estimated demand. The required water use restrictions in Lake Okeechobee Service Areas are assumed to have been met if users comply with the cutbacks as defined in the Supply-Side Management (SSM) Plan (Hall, 1991). There have been three times, to date, that the Water Shortage Plan has been invoked: 1982, 1985 and 1989.

One component in the operation of Lake Okeechobee is the determination of allowable water supply releases in order to meet irrigation requirements (demands) of the Lake Okeechobee Service Area. The report "The Lake Okeechobee Supply-Side Management Plan" (Hall, 1991) sets guidelines as to how these releases can be determined. This management plan states that "the amount of water available for use this period is a function of the anticipated rainfall, lake evaporation and water needs for the remainder of the dry season in relation to the amount currently in storage." After consultation with Allan Hall, the then Deputy Director of Operations and Maintenance Department, implementation of the SSM plan into the SFWMM was completed and a module was written to determine the cutback fraction to the total LOSA demand calculated on a daily basis (Trimble, 1992b; Brion, 1993). This section outlines the assumptions and algorithm used in the said module.

Table 3.2.1 Some Characteristics of Lake Okeechobee Service Areas

BASIN	SUBBASIN	ACREAGE	CONTROL STRUCTURE
Caloosahatchee	C-19 North of S-47B	7,830	C-5A
	Caloosahatchee	140,658	S-77
North Shore	S-131 (Lakeport)	2,773	S-131
	S-129	2,813	S-129
	S-127 (Buckhead Ridge)	519	S-127
	S-135 (J&S Park)	7,275	S-135
St. Lucie	St. Lucie	81,054	S-308
	L-8	9,263	C-10A
EAA	Culvert 16	320	C-16
	Pelican Lake Water Control District	1,600	C-13
	East Shore Water Control District	8,500	C-12
	South Shore Water Control District	4,430	C-4A
	East Beach Water Control District	7,000	C-10
	South Florida Conservancy Unit 5	9,775	2-36" pipes
	Townsite U.S. Sugar	8,960	2-33,000 gpm pumps
	S-169	34,833	S-169
	West Palm Beach Canal	124,352	S-352
	No. New River & Hillsboro canals	269,236	S-351
	Miami Canal	134,540	S-3/Siphon
TOTAL		855,731	

source: Hall (1991), Lake Okeechobee Supply-Side Management Plan. SFWMD. West Palm Beach, Florida.

General Characteristics of Supply-Side Management

The general assumptions and features of the SSM module in the model can be summarized as follows:

1. Supply-side management is fully implemented during the dry season (October 1- May 31). Wet season supply-side management is described briefly in item 8 below. An annual schedule, a time series of daily lake stages below which cutbacks due to supply-side management may be implemented (lower zones A-D in Fig. 3.1.3), describes when supply-side management should be implemented. In the model, if the lake stage goes below the SSM line (the line above the lower zone A in Fig. 3.1.3), supply-side management calculations are performed but

actual cutbacks may not be imposed. This condition will become evident in the succeeding discussions.

2. On any given day during a dry season, the lake stage may be projected to the end of the dry season. This is accomplished by subtracting the remaining (from the current day to the end of the dry season) normal water use and normal net evapotranspiration (ET-RF) volume from the lake storage corresponding to the current lake stage. (Note that normal allocation is equal to normal water use.) If lake stage is projected not to fall below 11 ft NGVD (the end-of-dry-season target stage), then normal water use for the current day may be discharged to the LOSA. If lake stage is projected to fall below the target, i.e., lake stage is at or below the SSM line in Fig. 3.1.3, then the allocation is reduced by the ratio of available storage to normal water use. Normal monthly rainfall, evapotranspiration and water use are calculated based on average monthly values starting from the dry season of 1970 and ending at the wet season of 1990, and a total irrigated area of 855,731 acres (Tables A1, A2, and 6 in Hall, 1991).
3. When supply-side management is implemented, the computed available storage is allocated based on normal monthly distribution of water demand. Therefore, normally high demand months would be allocated a larger portion of the available storage.
4. During the dry season some releases may be required from the lake for the purpose of preventing saltwater intrusion in the Lower East Coast (LEC) wellfields. The volume between 11 ft NGVD and 10 ft NGVD, approximately 327,000 ac-ft, is reserved for this purpose (Hall, 1991). In order to minimize LEC's impact on the normal allocation of lake water to LOSA, the target level on June 1 can be lowered to an amount equivalent to the total dry season surface water deliveries to the Lower East Coast (SUMLEC). This target stage reduction will, therefore, provide additional available storage to meet LOSA demands. This option is implemented on any day wherein the amount of calculated LOSA cutback becomes excessively high. This situation is arbitrarily defined at cutbacks levels equal to 67% or higher. This level of severity in cutback may be the cumulative effect of LEC deliveries earlier in the dry season, and that further cutbacks can be offset by changing the target level from 11 to 10 ft NGVD, thus making more lake water available to LOSA.
5. "Borrowing" allocation is allowed in this management scheme during the first four months of the dry season. Allocation for a given day, can be increased if the maximum allowable water supply release (SUPPLY) for that day falls short of the actual demand for the same day. This increase, however, is accompanied by a decrease in allocation four months later. The maximum allowable borrowing that can be done during any of the first four months of the dry season (October through January) is equal to one-third of the normal allocation of the corresponding month on the latter half of the dry season (February through May). For example, the maximum allowable borrowing allowed in November is equal to one-third the normal allocation for March which is approximately 28,000 ac-ft (see fourth column in Table 3.2.2). Although normal allocations are given in monthly values, maximum allowable borrowings are calculated on a daily basis (BORMAX) in order to maintain consistency with the simulation time step (1 day) in the SFWMM.
6. The amount of daily borrowing is limited by BORMAX while daily water supply release is equal to either the demand for the day (DMD) or the sum of SUPPLY and the actual amount of water borrowed (ACTBOR), whichever is smaller. They are calculated at the beginning of the week, implemented throughout the same week and updated at the beginning of the following week.

7. On any given day during one of the first four months of the dry season, credit is accrued if borrowing was performed earlier in the same month and climatological conditions create a situation wherein calculated water supply release exceeds actual demand. When this occurs, borrowed allocation may be "returned" to the corresponding month during the second half of the dry season. The allocation for the current month will, therefore, be reduced by the same amount. In essence, this procedure provides credit for any unused "borrowed" allocation.
8. If low lake storage conditions persist beyond the end of the dry season, i.e., should LOK stage fall below 11 ft NGVD, a target stage of 10.5 ft NGVD is set for August 1. This scenario triggers a wet season supply-side management scheme wherein simulated lake stages are compared against the supply-side management schedule. With a revised target lake stage of 10.5 ft NGVD, items 2, 3 and 4 are repeated. The same allocation technique is applied but the concept of borrowing and returning allocation no longer holds for this time period.

Model Implementation

A flowchart (Brion, 1993) showing the steps involved in the supply-side management module in the SFWMM is shown in Fig. 3.2.1. A short explanation of the overall algorithm follows.

The module, which comes in the form of a FORTRAN function, requires the following values for input: current month of year (MON), current day of the current month (IDAY), current Lake Okeechobee stage (STGLAKE), Lake Okeechobee Service Area demand for the day (DMD), current day water supply delivery to the Lower East Coast (DELLEC) and supply-side management schedule for the day (SCH). The output, SSMLAKE, is the actual water supply release or delivery from LOK to LOSA. SSMLAKE could also be referred to as the service area demand met for the day.

On the first day of the dry season (October 1), some variables are initialized [Fig. 3.2.1(a)]: the dry season day counter (IDAYCNT), the end of dry season LOK target storage (GOALSTO), and the borrowings from each month (BOR). There is a one-to-one relationship between lake stage and storage (Fig. 3.1.1) such that targets in terms of stage can be easily converted to storage targets, and vice versa. Since "credits" cannot be used to reduce the allowable allocations beyond the month when they are accrued, the variable CREDIT is initialized to zero at the beginning of each month.

At the beginning of each week, the maximum allowable daily borrowing (BORMAX) and the maximum allowable daily water supply release or allocation (SUPPLY) are determined [Fig. 3.2.1(b)] where DAYMON(MON) is the number of days in month MON. They are used for the entire week and are updated on the first day of the following week. BORMAX and SUPPLY are functions of the normal daily water use or allocation (WUDAY), the available storage (AVAIL) in the lake on the current day IDAY and the normal water use for the remainder of the dry season (REMUSE). Monthly and cumulative monthly normal values of lake ET, lake rainfall, and LOSA water use during the dry season are given in Tables 3.2.2 and 3.2.3, respectively. Initially, maximum allowable monthly demands are adjusted based on the previous week credit and borrowing. For credit accumulated from the previous week, the new allocation for month MON

will be the previous allocation minus the credit. Also, the new allocation for the fourth month (M4NEXT) after month MON will be its previous value plus the same amount of credit. A similar update is performed if borrowed water was accumulated from the previous week: month MON allocation will increase by the amount borrowed while month M4NEXT allocation will decrease by the same magnitude. The normal daily allocation (WUDAY) is, then, computed by dividing the revised monthly allocation by the number of days in the month. Likewise, the maximum allowable borrowing (BORMAX) is computed by taking one-third of the original allocation for month M4NEXT converted into a daily value.

Table 3.2.2 Normal Dry Season Lake ET and Rainfall, and EAA Water Use Incorporated in the Supply-Side Management Module of the South Florida Water Management Model

Month	LOK_ET (ac-ft)	LOK_RF (ac-ft)	EAA_WU (ac-ft)
OCT	126,720	89,472	52,402
NOV	118,203	66,917	68,135
DEC	96,999	76,702	73,548
JAN	104,599	88,589	53,115
FEB	119,551	105,900	54,751
MAR	171,687	120,991	84,581
APR	207,259	97,898	143,108
MAY	236,151	232,277	133,711

Table 3.2.3 Normal Cumulative Dry Season Lake ET and Rainfall, and EAA Water Use Incorporated in the Supply-Side Management Module of the South Florida Water Management Model

Month	LOK_ET (acre-ft)	LOK_RF (acre-ft)	EAA_WU (acre-ft)
OCT	1,181,169	878,746	663,351
NOV	1,054,449	789,274	610,949
DEC	936,246	722,357	542,814
JAN	839,247	645,655	469,266
FEB	734,648	557,066	416,151
MAR	615,097	451,166	361,400
APR	443,410	330,175	276,819
MAY	236,151	232,277	133,711

note: LOK area = 466,000 acres (~728 sq. miles); LOSA = 855,731 acres
source: Lake Okeechobee Supply-Side Management Plan (Hall, 1991)

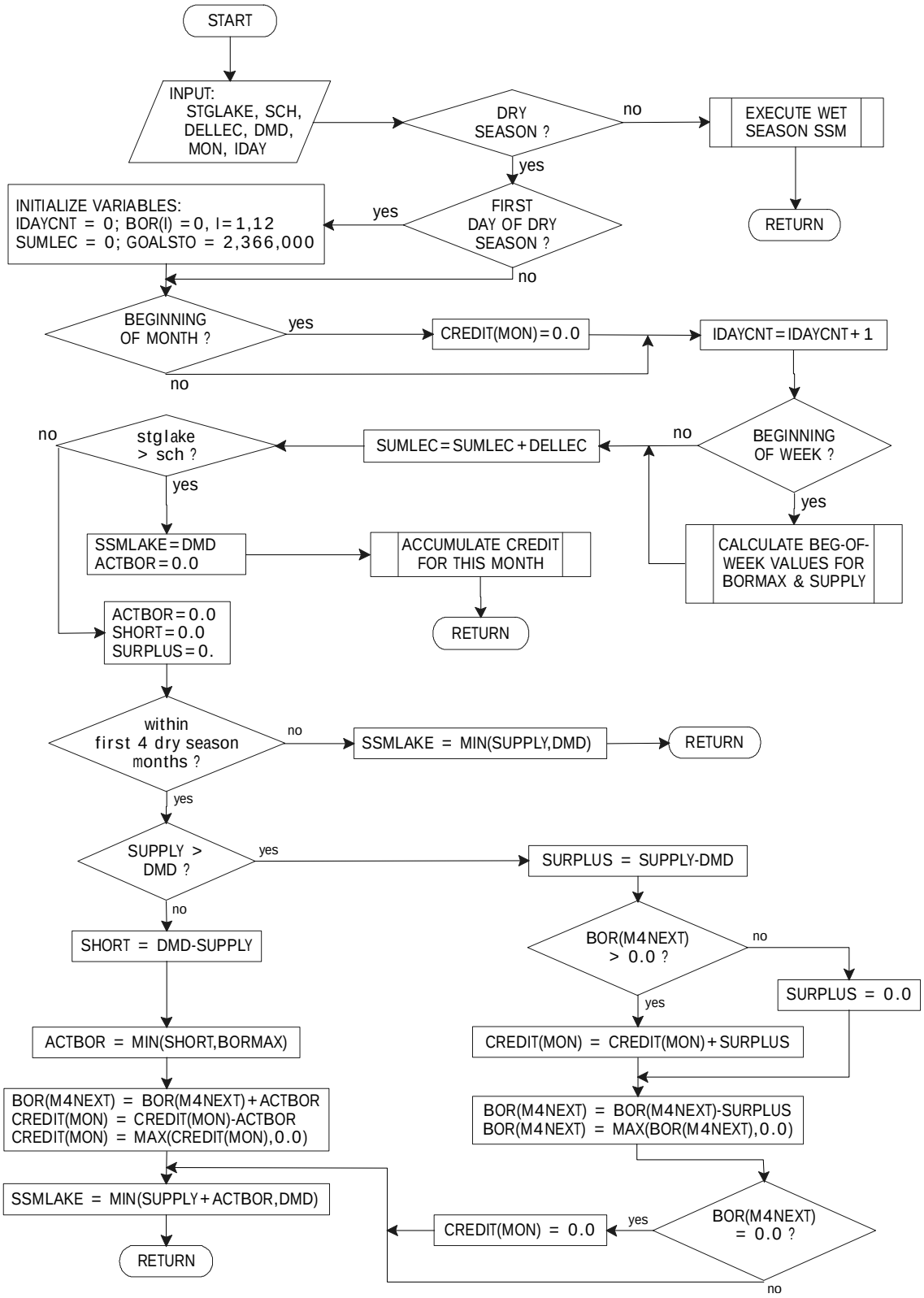

Figure 3.2.1(a) Flowchart for Supply-Side Management as Implemented in the South Florida Water Management Model

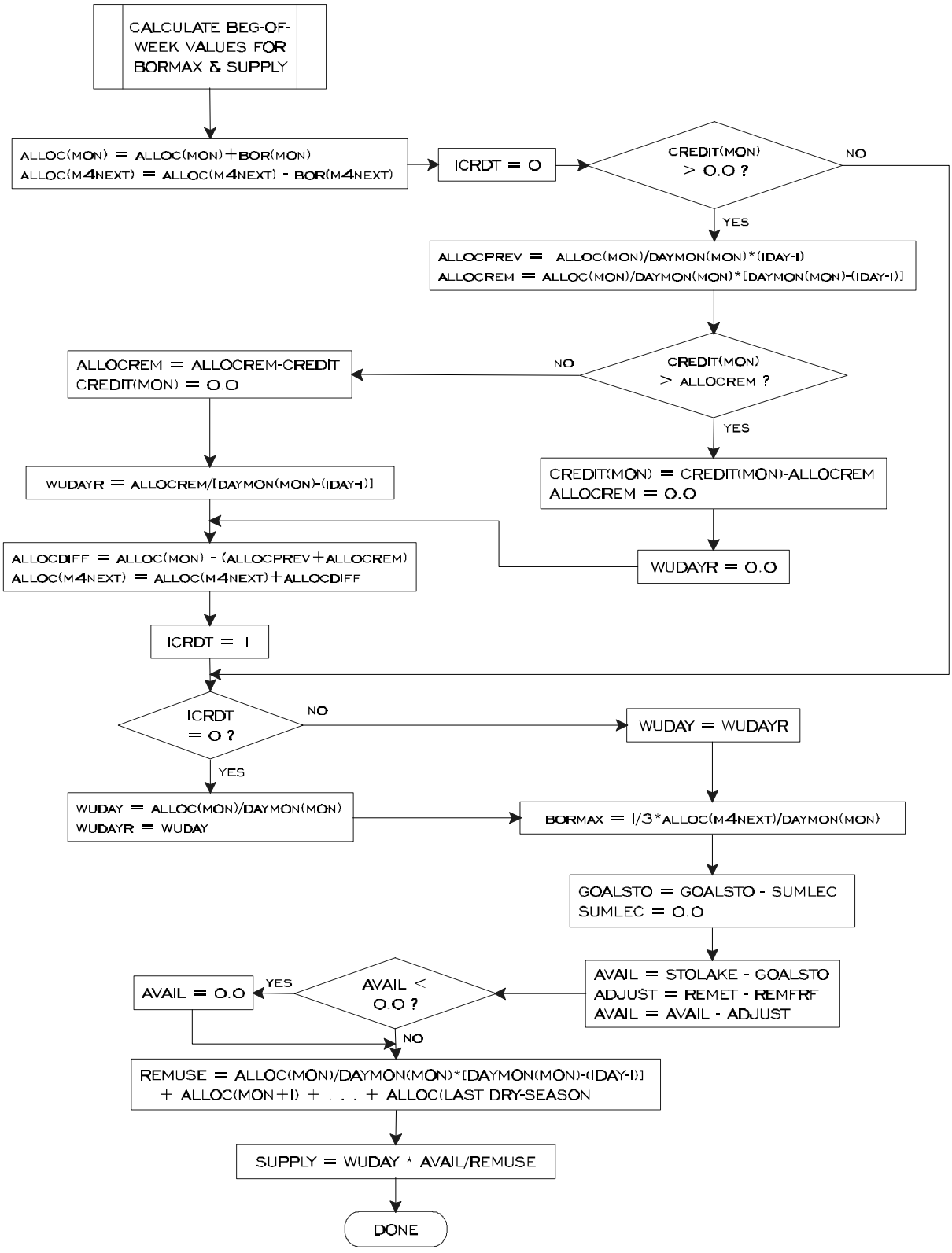

Figure 3.2.1(b) Flowchart for Supply-Side Management as Implemented in the South Florida Water Management Model

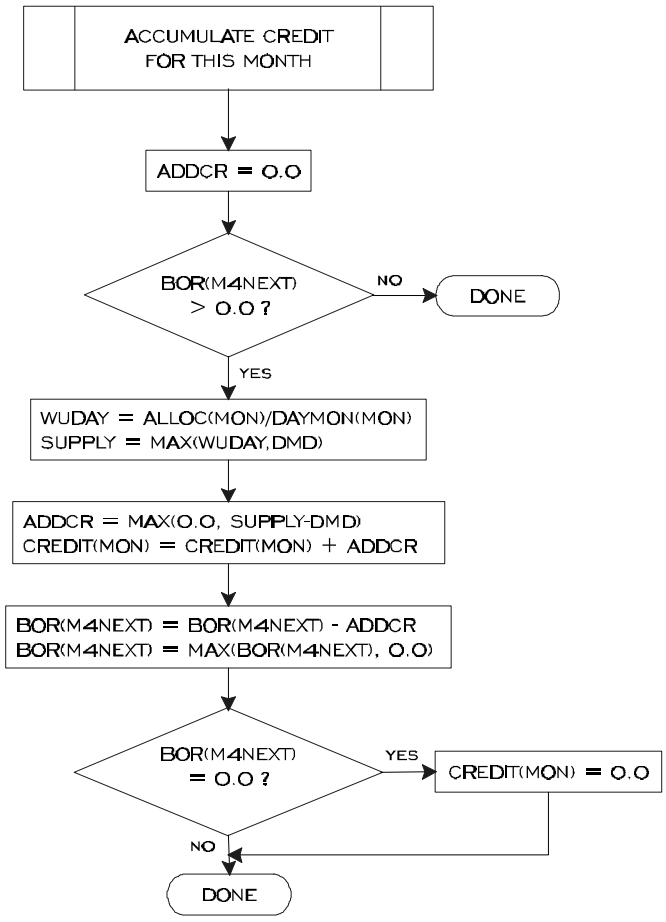

Figure 3.2.1(c) Flowchart for Supply-Side Management as Implemented in the South Florida Water Management Model

A slight variation in the calculation for WUDAY and BORMAX is used if the week straddles between two months (MON and MONEXT), each one having different normal monthly allocations. Prorated values are calculated based on the number of days the week has in month MON and in month MONEXT. The maximum allowable daily allocation (SUPPLY) is computed as the normal allowable daily allocation (WUDAY) multiplied by the ratio of the available lake storage (AVAIL) at the beginning of day IDAY and normal water use for the remainder of the dry season (REMUSE). The above steps are performed on October 1 and every seventh day thereafter which marks the starting day of each dry season week.

Next, the current lake stage is checked against the schedule for supply-side management [Fig.3.2.1(a)]. If it is above schedule, the actual water supply release is set equal to the full demand for the day. Also, credit for the month is incremented by the amount of SUPPLY in excess of DMD [Fig. 3.2.1(c)]. Again, credit will only be accumulated if borrowing has been done earlier in the current month. In Fig. 3.2.1(a), when the lake stage is below schedule: (a) the same credit update is performed if SUPPLY exceeds DMD; or (b) a shortage (SHORT) is calculated as the amount of DMD in excess of the SUPPLY. The actual borrowing for the day (ACTBOR) is the smaller value between SHORT and BORMAX. SHORT and ACTBOR are computed only if MON is October, November, December or January. The monthly allocation for

month MON is increased by ACTBOR while the allocation for month M4NEXT is decreased by the same amount.

Finally, the actual delivery to the lake service area (SSMLAKE) is the minimum between the current day's demand (DMD), and the sum of the maximum allowable daily allocation for the week (SUPPLY) and the actual borrowing for the day (ACTBOR).